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SPRINGFIELD ARMORY

SPRINGFIELD, MASSACHUSETTS

RESEARCH AND DEVELOPMENT

Report: SA-TR20-9209

Date: 8 August 1962

OCMS Code: 5110.22.01202

Report Title: Helicopter Accuracy Study

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Preparing Agency: Springfield Armory, Springfield, Massachusetts

CMS Code: 5110.22.01202

DA Project: 502-05-010

DA Project Title: Suppressive Fire Capabilities for Army Helicopter (Quad)

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ABSTRACT

A study was made to determine the accuracy of the XM153 (Quad) armament subsystem. Target acquisition and tracking capabilities of this subsystem were compared with those (results) presented in the referenced report. Basic accuracy of the 7.62mm M73 machine gun fired from the HU-1A helicopter equipped with the XM153 armament subsystem was determined. Also, basic accuracy of the 7.62mm M60 machine gun fired from the H-13H helicopter equipped with the XM2 armament subsystem was determined. Recommendations were made for improvement of the XM153 armament subsystem, and for future study and evaluation of the helicopter armament program. Test procedure is described and results discussed.

CONTENTS

SUBJECT

Target acquisition and tracking capabilities of the XM153 (Quad) armament subsystem, and accuracy determination of both subsystems (XM153 and XM2).

OBJECTIVES

The objectives of this study were as follows:

1. To check the target acquisition and tracking capabilities of the XM153 (Quad) armament subsystem and to compare these results with those presented in the referenced report.

2. To determine the basic accuracy of the 7.62mm M73 machine gun fired from an HU-1A helicopter equipped with the XM153 armament subsystem.

3. To determine the basic accuracy of the 7.62mm M60 machine gun fired from an H-13H helicopter equipped with the XM2 armament subsystem.

CONCLUSIONS

The conclusions drawn from the results of this study are as follows:

1. The XM153 (Quad) armament subsystem adjustments are so sensitive that proper bore-sighting is extremely difficult, if not impossible.

2. Tolerances of the components of the XM153 (Quad) armament subsystem result in an excessive rocking action of the weapons in the elevation plane because of recoil forces during out-of-phase weapon firing.

3. Deficiencies of the subsystem, together with the M73 weapon dispersion, indicate that this subsystem is not suitable presently for point target application.

4. Results of this test program show that the deviations in aircraft and sighting dispersion were found to be considerably greater in this test than those (deviations) given in referenced report.

5. Much larger dispersions were obtained from the weapon than from the sight as determined from camera runs with the mount and sight synchronized.

6. Hover firing resulted in increased round-to-round dispersion of approximately 2.5 times that of ground firing.

7. Basic accuracy results of the M60 from the H-13H helicopter indicate that the M60 weapon should be considered for future helicopter applications.

RECOMMENDATIONS

The following recommendations are submitted for the improvement of the helicopter armament systems:

1. Provide a ready, positive, and accurate boresight adjustment to improve the XM153 (Quad) armament subsystem. Also, provide separate elevation adjustments for each mount to compensate for the difference in tolerances between the mounts and the assemblies.

2. Conduct tests with the M60C weapons and improved XM153 subsystem on the HU-1A and HU-1B helicopters to determine the potential of this subsystem for desired tactical employment.

3. Initiate a study to determine a satisfactory method of recording the weapon line of sight during burst-firing

4. Establish accuracy requirements for air-to-ground and air-to-air roles for helicopter armament systems.

5. Conduct investigations to determine the possibility of obtaining a more stable firing platform for the HU-1 aircraft series.

6. Investigate the possibility of improving the fire control system to minimize the effect of aircraft instability for improved air-to-air accuracy capability.

7. Conduct an investigation to determine the feasibility of a larger caliber system (20mm or larger) for the HU-1 aircraft series. Include in this investigation point and area air-to-ground capabilities as well as air-to-air capabilities.

8. Conduct accuracy evaluation of the prototype M39 weapon mount installed on the H-34 helicopter. (The results of such an investigation could be applied to future development of the 20mm helicopter armament system.)

9. Conduct a study of the gun-boosted rocket system for helicopter application for both point and area target roles. Include in this study methods of reducing and controlling round impulse and its effect upon the helicopter.

10. Investigate the accuracy of the XM138 armament system used on the HU-1 helicopter series.

1. INTRODUCTION

The XM153 (Quad) armament subsystem consists of two power-operated flexible gun mounts, one mount on each side of the helicopter (Photograph 764, Appendix C), a sighting station (No. 524525), and a control panel, as well as solenoid-operated trigger mechanisms and hydraulic charges for each machine gun. This subsystem is more completely described in the referenced report (Paragraph 2).

Because function and endurance tests of an M73 weapon were scheduled, a concurrent evaluation of the XM153 sighting system was made to verify the results given in the referenced report. In addition, basic accuracy and location of center of impact relative to sighting position for various ranges and helicopter altitudes and speeds were determined. The XM153 (Quad) armament subsystem tested was a prototype and had not been designed for air-to-air point target requirements. This subsystem was used only because it was a convenient test vehicle for the function tests of the M73 on the HU-1A helicopter. These function tests provided an opportunity to evaluate the future capabilities of this subsystem.

Upon completion of the M73 function tests, the HU-1A helicopter (Photograph 764) was no longer available at the Armory. Therefore, the basic accuracy tests of the M60 machine gun were confined to the H-13H helicopter (Photograph 1498) with the XM2 armament subsystem. A detailed close-up view of the two armament subsystems is shown in Photograph 765 (XM153C) and Photograph 1494 (XM2). Also Photograph 1498 is a view of the XM1 armament subsystem converted from the caliber .30M37 weapon to the GPMG 7.62mm M60 weapon.

2. REFERENCE

Emerson Electric Manufacturing Company, Report 1165, "Final Report of Project HOTAC II, Helicopter Optical Tracking and Control Unit".

3. TEST MATERIAL

a. HU-1A Helicopter, S/N 59-1625
b. H-13H Helicopter, S/N 58-1523
c. XM153, (Quad) Armament Subsystem
d. XM2 Armament Subsystem
e. AN/N6A Cameras
f. Range and Target Facilities

4. PROCEDURE AND DISCUSSION

a. The XM153 (Quad) armament subsystem, consisting of No. 524525 sighting system and Quad mount with four M73 machine guns, was installed on the HU-1A helicopter. The top weapon on each of the two mounts was boresighted at a 450-yard range. Adequate boresighting of this system was not possible because of the following reasons:

(1) Adjustment sensitivity of the potentiometer settings prevented the gunner from holding the sight "on" target during the boresight operation.

(2) Lack of separate elevation adjustment for individual gun mounts prevented both of the top weapons from being properly boresighted in the elevation plane. The bias between the mounts is a constant determined by the physical dimensions and tolerances of the weapon-mount combination. Results of the boresighting operation were as follows:

(a) Fairly good alignment in azimuth plane,

(b) Difference of approximately 30 feet at 450 yards in elevation between the top weapons on each mount.

(c) Notification of boresight problems to contractor.

Cameras were mounted to the sight and to the right gun mount, and two firing runs were conducted. The results of these firing runs are given in Table I, Appendix A. Because of the extremely low number of hits on a 20' X 20' target at 600 yards, an additional 1200 rounds were fired from hover at this range. Careful examination of the target cloth revealed no target hits which indicated that the sight picture was not synchronized with the line of fire.

b. At this time, the weapons were zeroed by actual firing at a 600 yard range. The results of this ground-firing confirmed the belief that either the weapons and/or the sighting system had shifted excessively. A third on-target firing run was conducted. Results obtained from the previous zeroing were used in this firing run. Only two hits resulted from the 200 rounds fired (50 rounds for each weapon).

Because of the condition of the sighting system which prevented long-range target acquisition, basic accuracy of the weapon was obtained at 1000-inch range. A sight picture was determined that allowed the rounds fired from all weapons to be recorded on two 5-foot-square targets approximately 1000 inches from the barrel muzzle. The following six firing runs were conducted:

Run	Range (in.)	Rounds Loaded, Weapon	Number Weapons	Camera Location	Helicopter Position
1	1000	20	3	Sight and right mount	Ground
2	1000	30	3	Sight and right mount	Ground
3	916	30	3	None	Hover (2-foot)
4	916	30	4	Sight and right mount	Ground
5	1000	30	4	None	Ground
6	1000	30	4	Sight and right mount	Hover (1-foot)

The analysis of the target data is given in Table II of Appendix A.

With the use of cameras, a boresight check was made at 575 yards between the second and the third firing runs. The following results were noted;

(1) Sight camera and sight, in good alignment,

(2) Boresight of gun mount camera, 10-15 feet below boresight of the right top weapon.

(3) Boresight of sight camera, approximately 30 feet below boresight of the gun mount camera.

The sight pictures from both cameras (sight and weapon) were essentially the same at the completion of the sixth firing run.

The films were made to determine: (1) the ability of the gunner to hold the sight on target during firing, (2) the dispersion of the weapon line of sight during firing, and (3) the relationship between weapon and sight throughout the firing burst, i.e., the time-lag characteristics of the system. The excessive weapon vibration during burst-firing resulted in unsatisfactory film records from the gun-mount camera. Therefore, correlation between sight and gun mount during firing phases could not be determined.

c. An attempt was made (by a representative of the contractor) to boresight the weapon-mount system. A check of the results of this boresighting indicated a difference of 0.6 degree between the top weapons of the mounts. A firing test, in which the 20-foot square targets were used at a 575-yard range, resulted in zero hits from 200 rounds. At this time, the test program was limited to dry-run photography at various ranges and to basic accuracy of the system at 1000 inches.

d. The camera runs were conducted at various altitudes, ranges, and flight conditions. The schedule for this phase of the program is listed as Table III, Appendix A. Results of even-numbered runs were analyzed; plots of sight elevation, sight deflection, aircraft pitch, and aircraft yaw axes are presented in Appendix 13. Film records, noted as "Gun Mount Not Synchronized," were made with the mounting system disconnected from the sight so that the mount camera recorded aircraft movement. The films with "Gun Mount Synchronized" allow for comparison and evaluation of the relationship between sight and weapon during the dry-run test phase. The simulated firing time represents the on-target time as estimated by the gunner from his visual sight picture. These data including linear standard deviations, sight radial standard deviation, and probable error are summarized and presented in Tables IV, V, and VI, respectively (Appendix A).

The average sight-holding characteristics (standard deviation) obtained from the curves analyzed were 5.8 mils and 6.4 mils in deflection and elevation, respectively, as stated in referenced report. In addition, this referenced report lists average HU-1A aircraft deviations of 17.3 and 12.2 mils for yaw and pitch, respectively, compared with the Armory results of 54.1 and 31.5 mils. The Armory test allows for further comparison of sight and weapon deviation during simulated synchronized firing. The average standard deviations are:

	Deflection (mils)	Elevation (mils)
Sight	5.6	7.2
Weapon (right mount)	14.3	9.6

e. The basic accuracy of the M73 weapons fired from the Quad mount and the HU-1A helicopter was determined by firing all possible weapon combinations at a 1000-inch range from both ground and hover positions. The test plan is illustrated in Table VII, Appendix A.

The results of these accuracy tests are contained in Table VIII, Appendix A, in which target misses (in the overall determination of the standard deviation) have been considered in the calculations. Review of these results indicates greater vertical dispersion than horizontal dispersion, and shows that hover dispersions are approximately two to three times those of ground firing. Accuracy data obtained at 1000 inches are summarized and presented in Appendix B.

4. PROCEDURE AND DISCUSSION - continued

f. The restricted availability of the H-13H helicopter resulted in the limited test-firing of the M60 from an XM2 armament subsystem. This subsystem provides for the installation of one M60 weapon on each side of the aircraft. The weapons were boresighted at 1000 inches and targets were obtained for both hover and ground firing at 1000 inches, and for ground firing at a 600-yard range. The following accuracy results were obtained:

Run #	Range	Weapon	Position	Rounds Fired	Hits	σ_x (mils)	σ_y (mils)
1	1000 in.	Left side	Ground	30	30	1.0	0.9
		Right side					
2	1000 in.	Left side	Hover	30	30	9.6*	5.7*
		Right side		30	30	9.6	8.0
3	600 yd.	Left side	Ground	50	50	1.1	1.6
		Right side		50	12	- -	- -

* Computations adjusted for target misses.

APPENDICES

A - Tables

B - Charts and Graphs

C - Photographs

D - Distribution

TABLE I

M73 - Preliminary Test Results (600 yards)

Gun Location	Gun Number
Top right	383
Bottom right	421
Top left	292
Bottom left	431

Run 1	Run 2*
Range, 600 yds	Range, 575 yds
Altitude, 5-10 ft	Altitude, 5-10 ft

Guns No.	Rds Loaded	Rds Fired	Hits	Rds Loaded	Rds Fired	Hits
383	50	50	6	50	50	0
421	50	0	-	50	50	1
292	50	50	0	50	50	0
431	50	6	0	50	10	0

* Film recorded on dry run and during firing phase.

TABLE II

M73 Preliminary Test Results (1000 inches)

Three Guns

Run	Gun Position	Helicopter Position	Distance (In.)	Rounds	σ_x (Mils)	σ_y (Mils)
1	Top right			20	3.3	8.1
	Top left	Ground	1000	19	6.0	13.4
	Bottom left			20	3.4	7.9
2	Top right			30	2.2	6.4
	Top left	Ground	1000	30	6.3	13.1
	Bottom left			30	4.3	5.4
3	Top right			25	9.1	13.0
	Bottom right	Hover*	916	29	6.6	7.6
	Bottom left			30	5.6	9.0

Four Guns

4	Top right			30	4.8	9.4
	Bottom right	Ground	916	30	5.3	5.7
	Top left			29	5.6	10.8
	Bottom left			30	4.7	5.3
5	Top right			30	6.0	8.6
	Bottom right	Ground	1000	30	4.5	7.8
	Top left			30	6.6	11.4
	Bottom left			30	5.1	4.4
6	Top right			30	7.1	9.2
	Bottom right	Hover*	1000	30	5.9	6.8
	Top left			30	6.8	12.7
	Bottom left			28	6.6	6.2

*1 - to 2-foot altitude

TABLE III

CAMERA RUN SCHEDULE

(Cameras mounted on sight and on right gun mount)

Run	Gun Mount Synchronized	Hover	Camera Start (range, yds.)	Helicopter Velocity (knots)	Camera Run Time (sec., approx.)	Altitude (ft.)
1	NO	YES	600	0	15	220
2	NO	YES	600	0	15	220
3	NO	YES	300	0	15	20
4	NO	YES	300	0	15	20
5	NO	NO	600	60	--	225
6	NO	NO	600	60	--	225
7	YES	YES	600	0	15	175
8	YES	YES	600	0	15	175
9	YES	YES	300	0	15	20
10	YES	YES	300	0	15	20
11	YES	NO	600	60	--	225
12	YES	NO	600	60	--	225

TABLE IV

M73 Quad Subsystem, HU-1A Helicopter

Dry Run, Camera Data

Pass No.	Gun Mount Synchronized	Hover	Altitude (Ft.)	Camera Start (Range, yds)	Hel. Velocity (Knots)	Sight Camera * Std. Deviation (Mils) Deflection	Elevation	Gun Camera Std. Deviation (Mils) Yaw	Pitch
2	NO	YES	220	600	0	6.6	4.6	89.9	30.3
4	NO	YES	20	300	0	6.8	5.5	56.1	14.1
6	NO	NO	225	600	60	4.7	6.4	16.3	50.0
8	YES	YES	175	600	0	5.1	4.9	13.8	9.0
10	YES	YES	20	300	0	5.4	8.6	14.5	8.9
12	YES	NO	220	600	60	6.3	8.2	14.4	11.0

* Simulated Firing Only

TABLE V

M73 Quad Subsystem, HU-1A Helicopter

Dry Run, Camera Data

Sight Radial Standard Deviation by Altitude

20' - 25',	9.47 (Mils)
150' - 200',	7.07 (Mils)
220' - 250',	8.84 (Mils)

Note: Sight radial standard deviation is the square root of the sum of the squares of the sight deviations for the altitude involved.

TABLE VI

Sight Probable Error (Mils)

Sight Deviation		Sight Probable Error	
Deflection	Elevation	Deflection	Elevation
6.6	4.6	4.5	3.1
6.8	5.5	4.6	4.7
4.7	6.4	3.2	4.3
5.1	4.9	3.4	3.3
5.4	8.6	3.7	5.8
6.3	8.2	4.3	5.5

TABLE VII

Target Schedule

Range 1000 Inches, Ground and Hover *, 30 Rounds/Gun

	GUNS			
Target No.	Top Left	Top Right	Bottom Left	Bottom Right
1 & 2	X	X	X	X
3 & 4	X			
5 & 6		X		
7 & 8	X	X		
9 & 10			X	
11 & 12				X
13 & 14			X	X
15 & 16		X		X
17 & 18	X		X	
19 & 20		X	X	
21 & 22	X			X
23 & 24	X	X	X	
25 & 26	X	X		X
27 & 28	X		X	X
29 & 30		X	X	X

* 3-foot altitude

TABLE VIII

TARGET DATA

M73 Quad Subsystem, HU-1A Helicopter

	GUN POSITIONS				HELICOPTER POSITIONS					
	Top Right	Top Left	Bottom Right	Bottom Left	GROUND			HOVER		
	1	2	3	4	HITS	σ_x (MILS)	σ_y (MILS)	HITS	σ_x (MILS)	σ_y (MILS)
SINGLE	(1)	TOP RIGHT			30	2.4	1.7	30	6.4	7.9
	(2)	TOP LEFT			30	1.1	3.6	30	9.2	6.7
	(3)	BOTTOM RIGHT			30	3.6	3.7	29**	5.1	8.7
	(4)	BOTTOM LEFT			27*	1.6	2.3	30	5.1	6.5
DUAL	(1)	TOP RIGHT			30	1.7	3.2	30	5.4	6.7
	(2)	TOP LEFT			30	2.0	4.9	29**	7.7	9.0
	(1)	TOP RIGHT			30	4.3	5.5	30	8.3	8.3
	(3)	BOTTOM RIGHT			30	2.5	3.6	30	7.8	10.9
	(1)	TOP RIGHT			30	3.1	3.9	30	10.7	6.6
	(4)	BOTTOM LEFT			30	2.5	3.2	30	11.1	6.5
	(2)	TOP LEFT			30	1.9	4.1	30	13.5	8.3
	(3)	BOTTOM RIGHT			30	3.4	5.4	21**	10.8	6.5
	(2)	TOP LEFT			30	4.1	3.6	26**	13.7	16.5
	(4)	BOTTOM LEFT			30	2.8	4.6	30	12.7	11.2
	(3)	BOTTOM RIGHT			30	3.4	4.9	27**	12.2	12.4
	(4)	BOTTOM LEFT			30	2.3	3.5	30	12.3	8.9
THREE	(1)	TOP RIGHT			30	4.0	4.3	30	13.6	8.8
	(2)	TOP LEFT			30	2.6	4.4	30	13.3	14.4
	(3)	BOTTOM RIGHT			30	4.2	5.9	30	11.3	8.6
	(1)	TOP RIGHT			30	2.8	4.0	30	4.8	6.8
	(2)	TOP LEFT			30	5.4	7.0	30	4.6	9.1
	(4)	BOTTOM LEFT			30	2.8	5.2	30	6.2	7.8
	(1)	TOP RIGHT			30	4.3	9.0	30	10.1	5.1
	(3)	BOTTOM RIGHT			30	3.3	6.2	30	6.9	7.7
	(4)	BOTTOM LEFT			30	2.3	4.7	30	8.4	5.1
	(2)	TOP LEFT			30	5.3	8.1	30	11.1	17.8
	(3)	BOTTOM RIGHT			30	3.3	6.5	29**	15.1	10.5
	(4)	BOTTOM LEFT			30	3.1	6.4	30	14.6	15.1
FOUR	(1)	TOP RIGHT			30	3.1	6.1	28**	8.8	13.6
	(2)	TOP LEFT			30	4.3	8.3	29**	11.0	15.8
	(3)	BOTTOM RIGHT			30	3.2	5.7	24**	9.4	10.8
	(4)	BOTTOM LEFT			30	3.3	4.8	29**	8.8	13.9

* No misses. Only 27 rounds fired.

** Rounds less than 30 signify missed target; calculations adjusted for misses.

TABLE IX

Mean Averages, Individual Guns

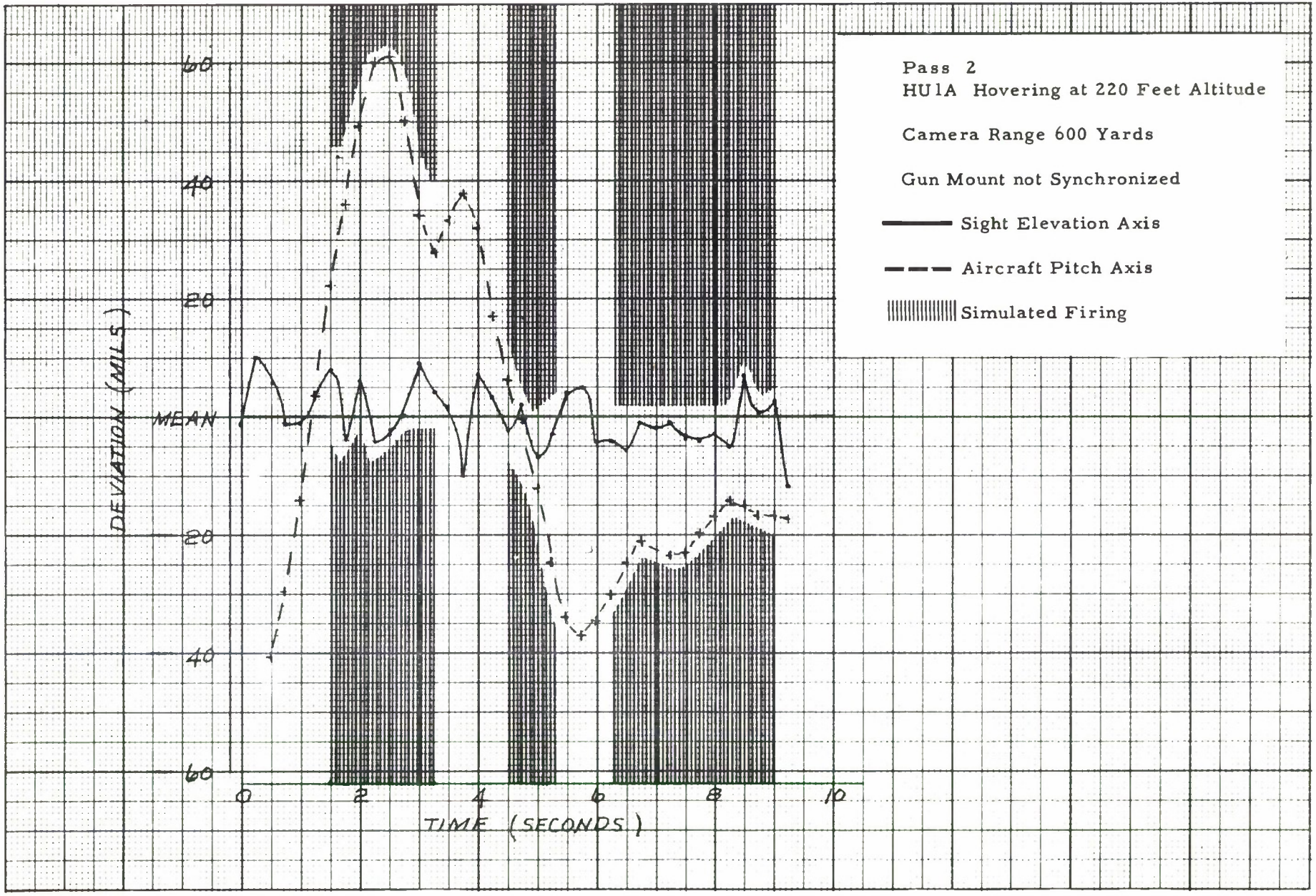
GUNS	RUNS	GROUND		HOVER	
		σ_x	σ_y	σ_x	σ_y
Single	4	2.2	2.8	6.5	7.5
Dual	6	2.8	4.2	10.5	9.3
Three	4	3.6	6.0	10.0	9.8
Four	1	3.5	6.2	9.5	13.5

APPENDIX B

1. Charts (12) obtained from dry-run films of six separate passes, illustrating:

a. Aircraft yaw deviation,
b. Sight deflection deviation,
c. Aircraft pitch deviation,
d. Sight elevation deviation,
e. Simulated firing time.

2. Graphs (2) of accuracy (standard deviation) data summarized showing ground and hover conditions of the M73 Quad subsystem on the Hu-1A helicopter.


Pass 2
HU1A Hovering at 220 Feet Altitude
Camera Range 600 Yards
Gun Mount not Synchronized
Sight Elevation Axis
Aircraft Pitch Axis
Simulated Firing
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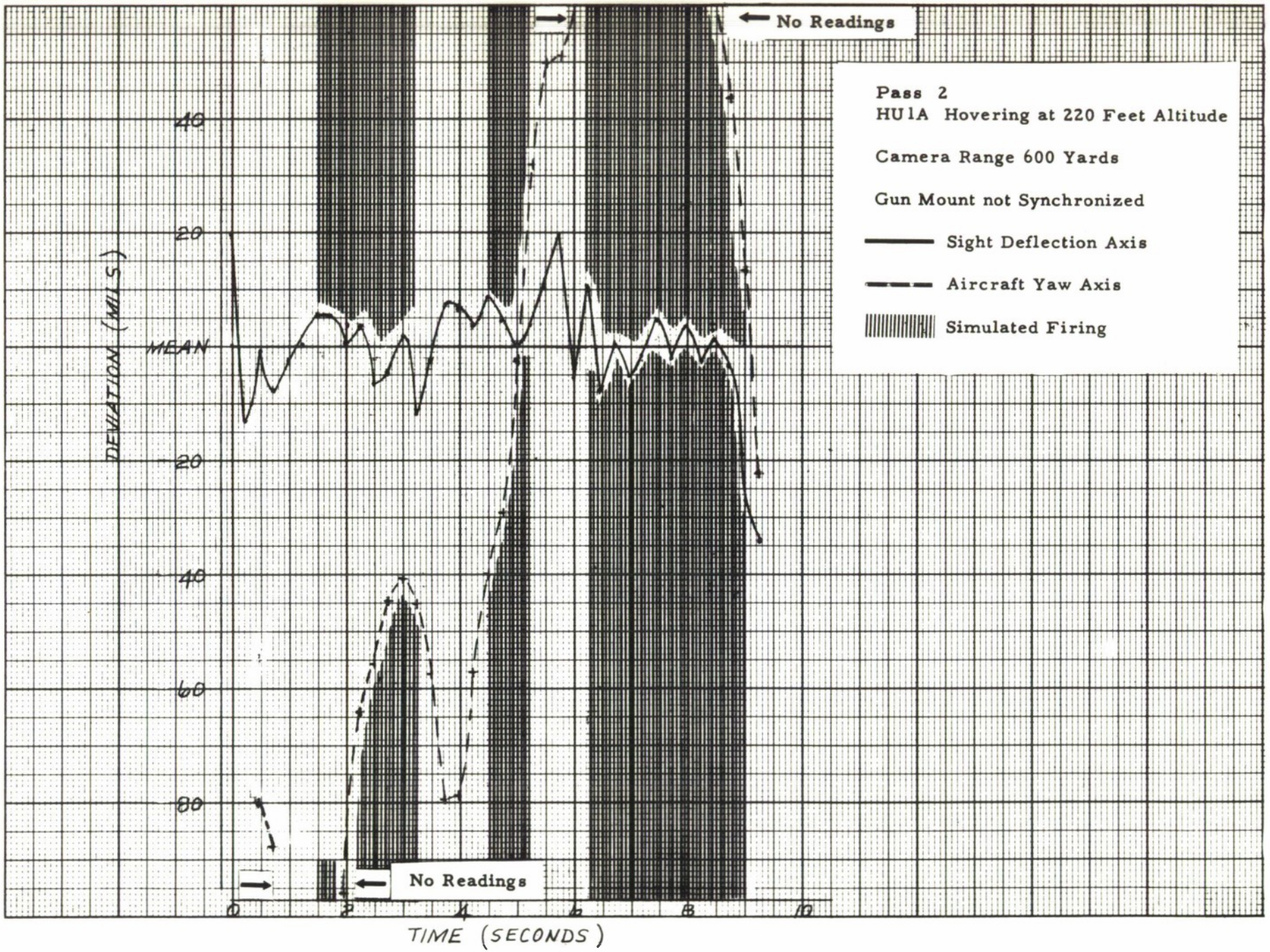
40
20
MEAN
20
40
60
DEVIATION (MILS)
0
2
4
6
8
10
TIME (SECONDS)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Camera Range 600 Yards
Gun Mount not Synchronized
Sight Deflection Axis
Aircraft Yaw Axis
Simulated Firing
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MEAN
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DEVIATION (MILS)
No Readings
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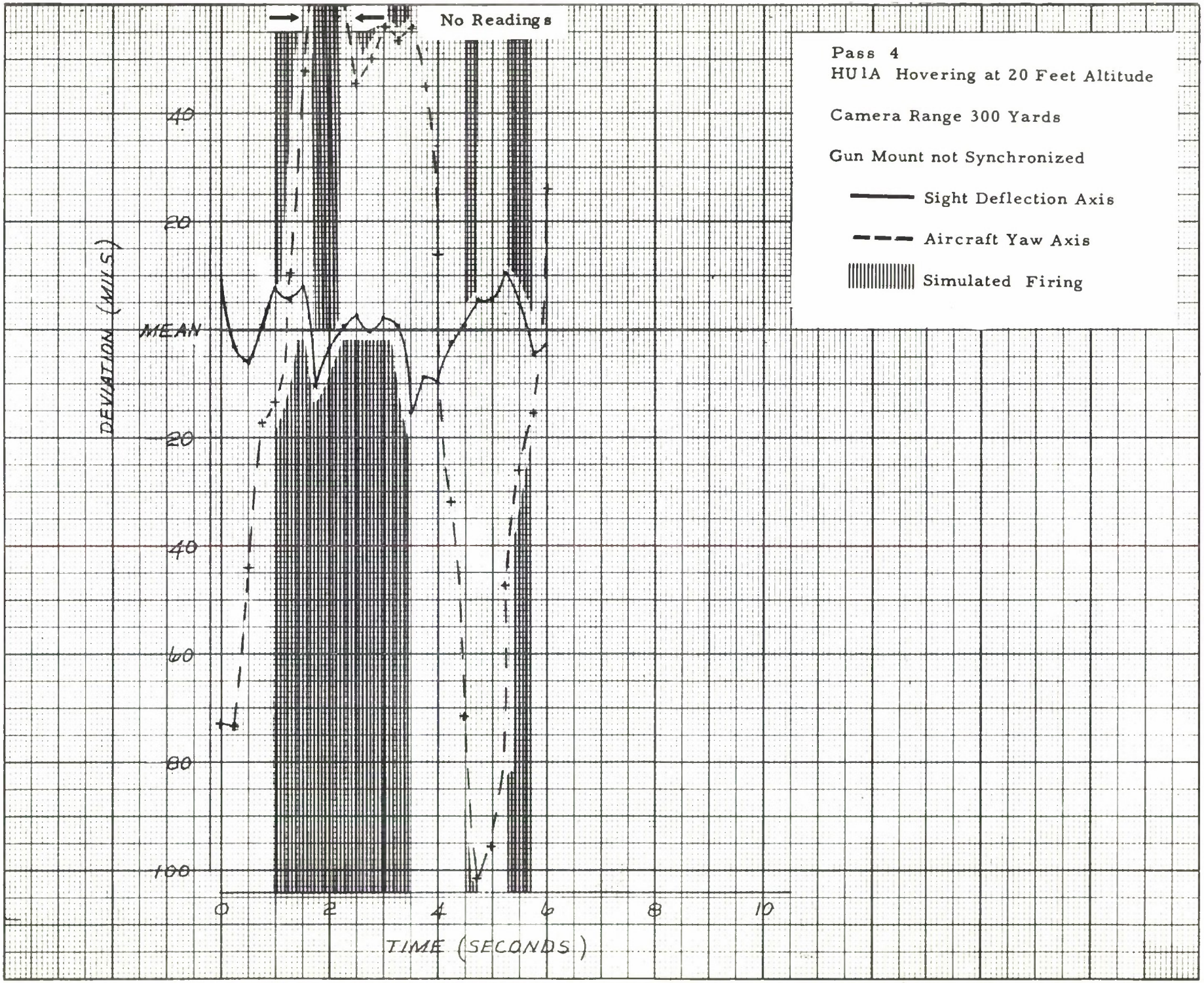
2
4
6
8
10
TIME (SECONDS)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Camera Range 300 Yards
Gun Mount not Synchronized
Sight Deflection Axis
Aircraft Yaw Axis
Simulated Firing
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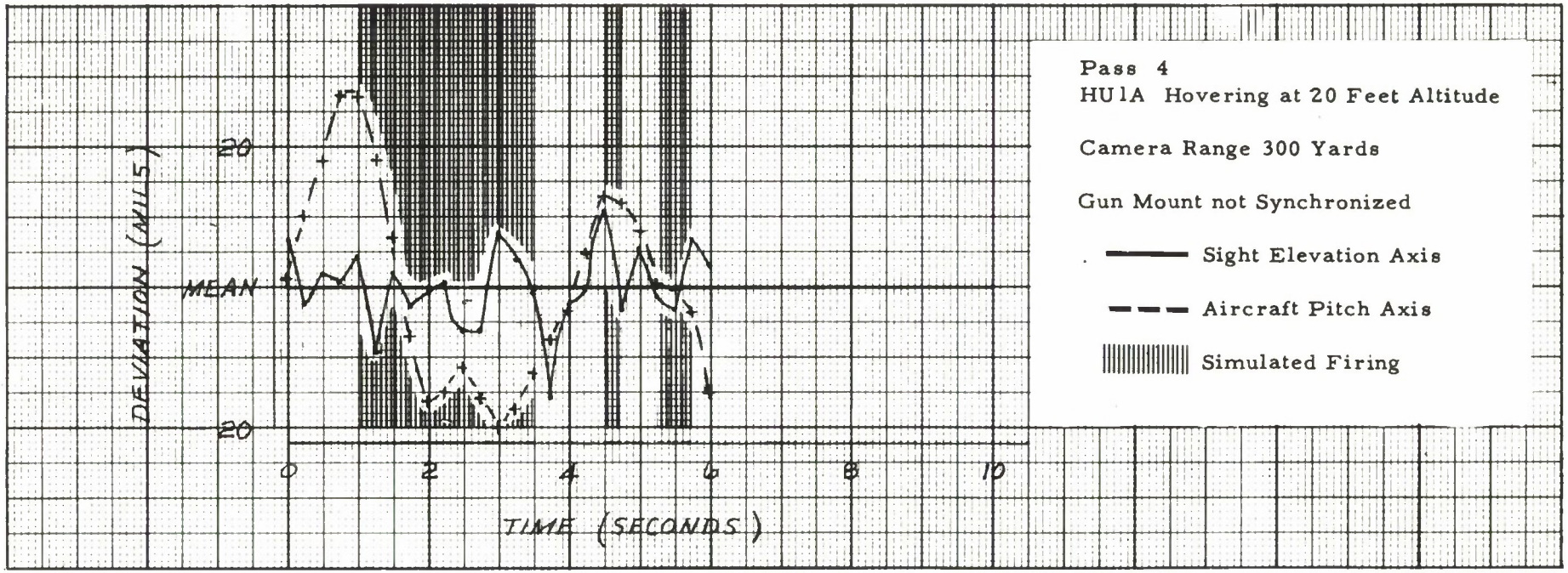
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Aircraft Pitch Axis
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DEVIATION (MILS)
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2
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6
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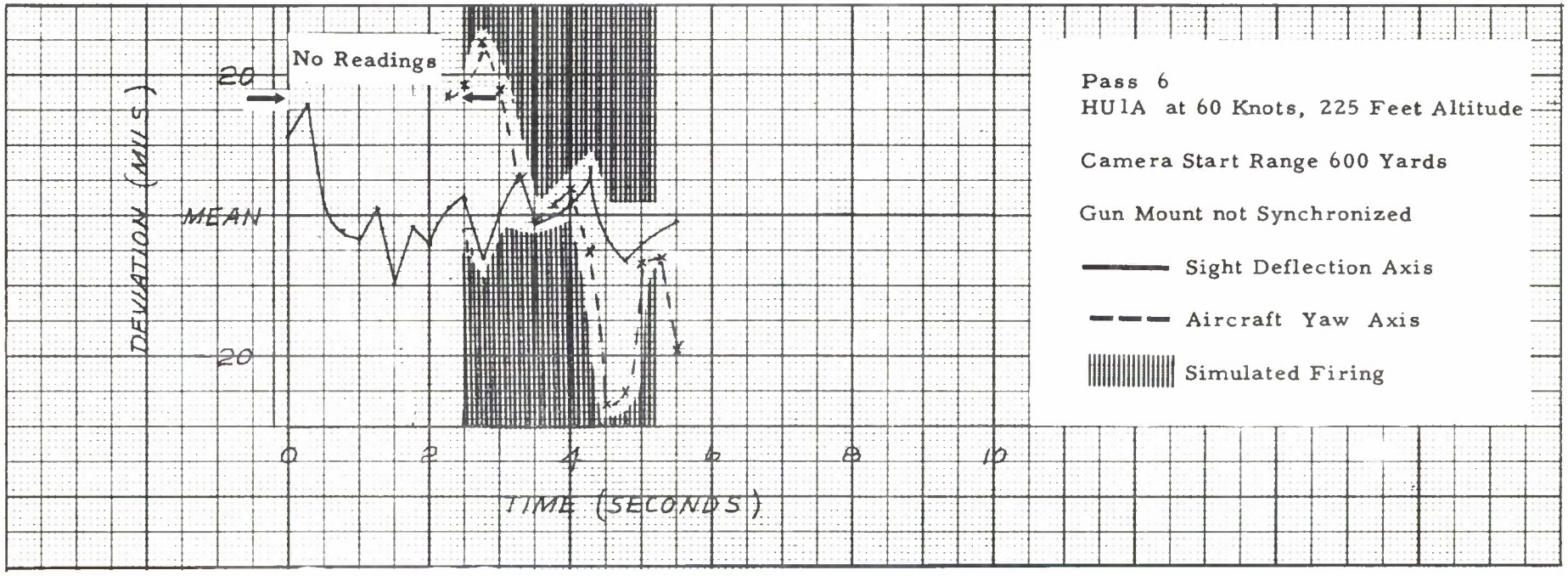
10
TIME (SECONDS)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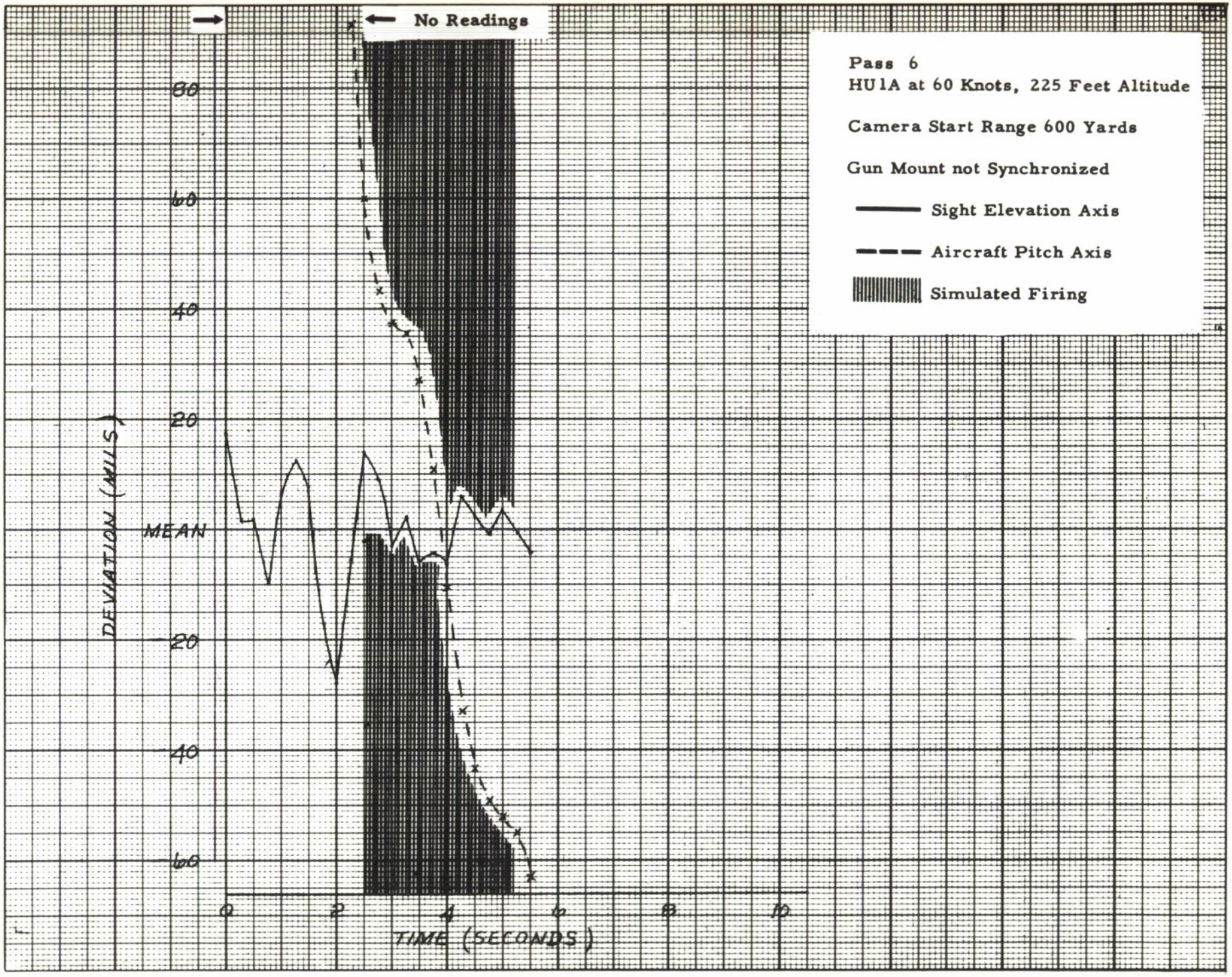
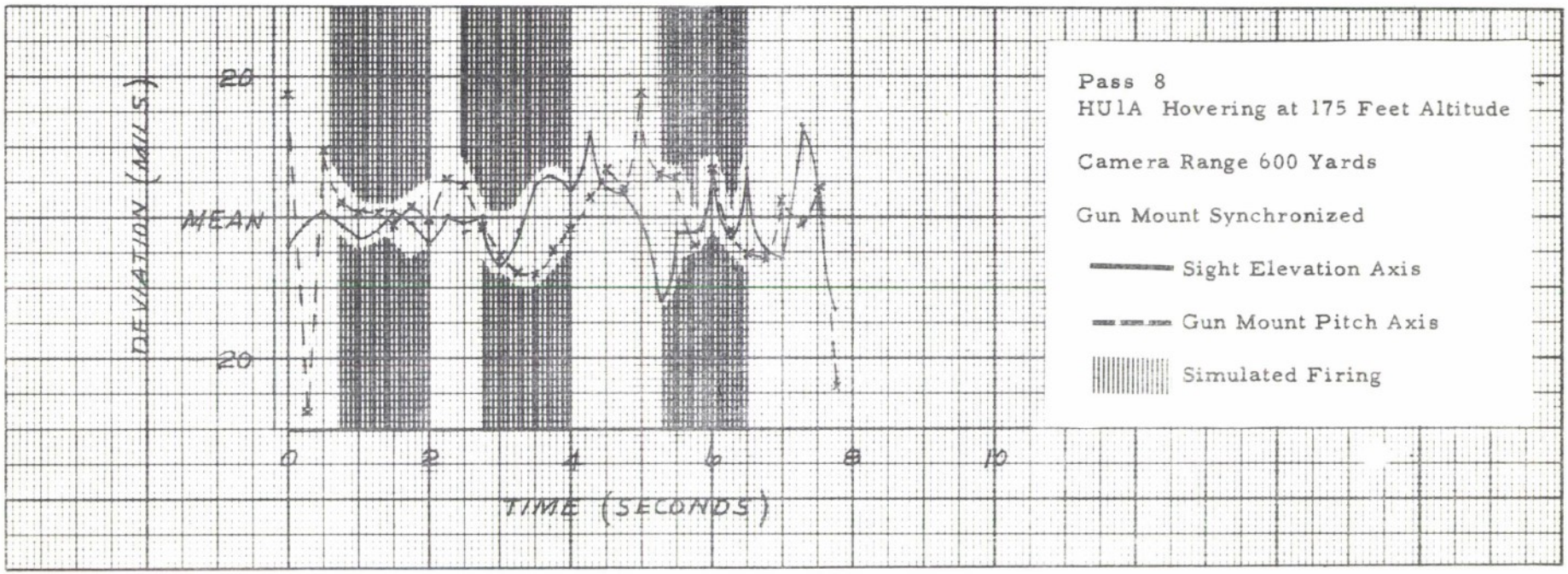
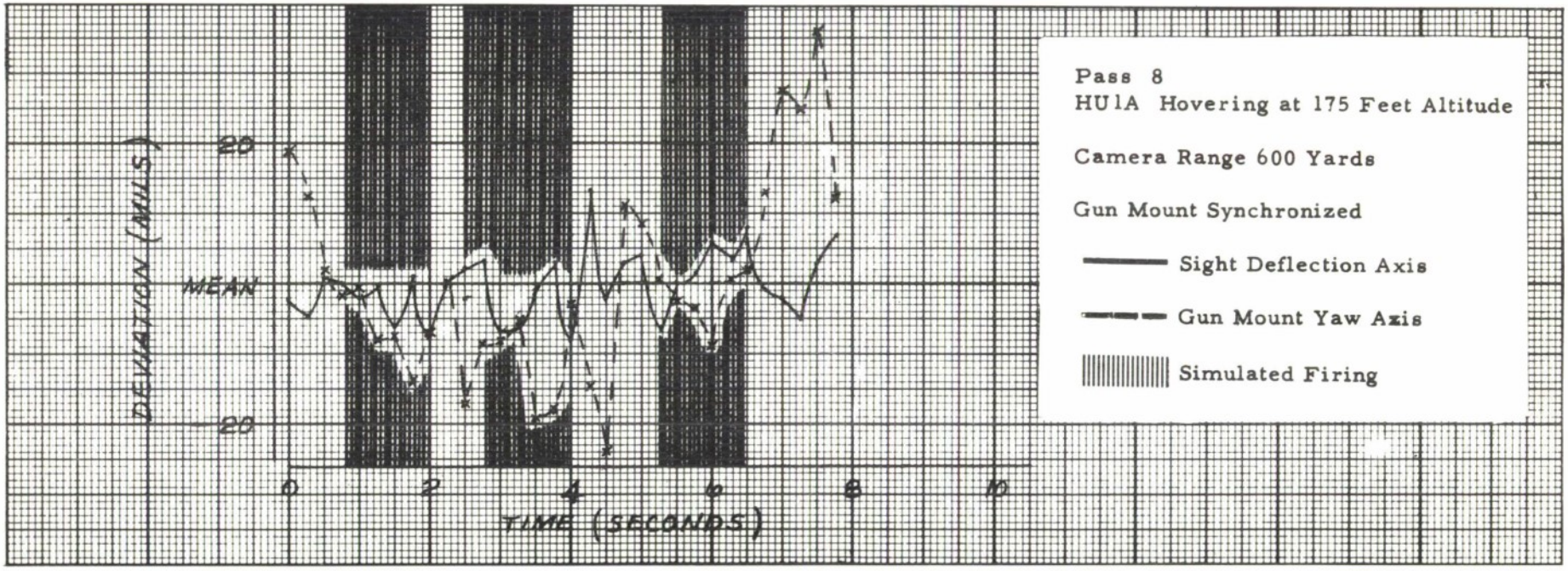
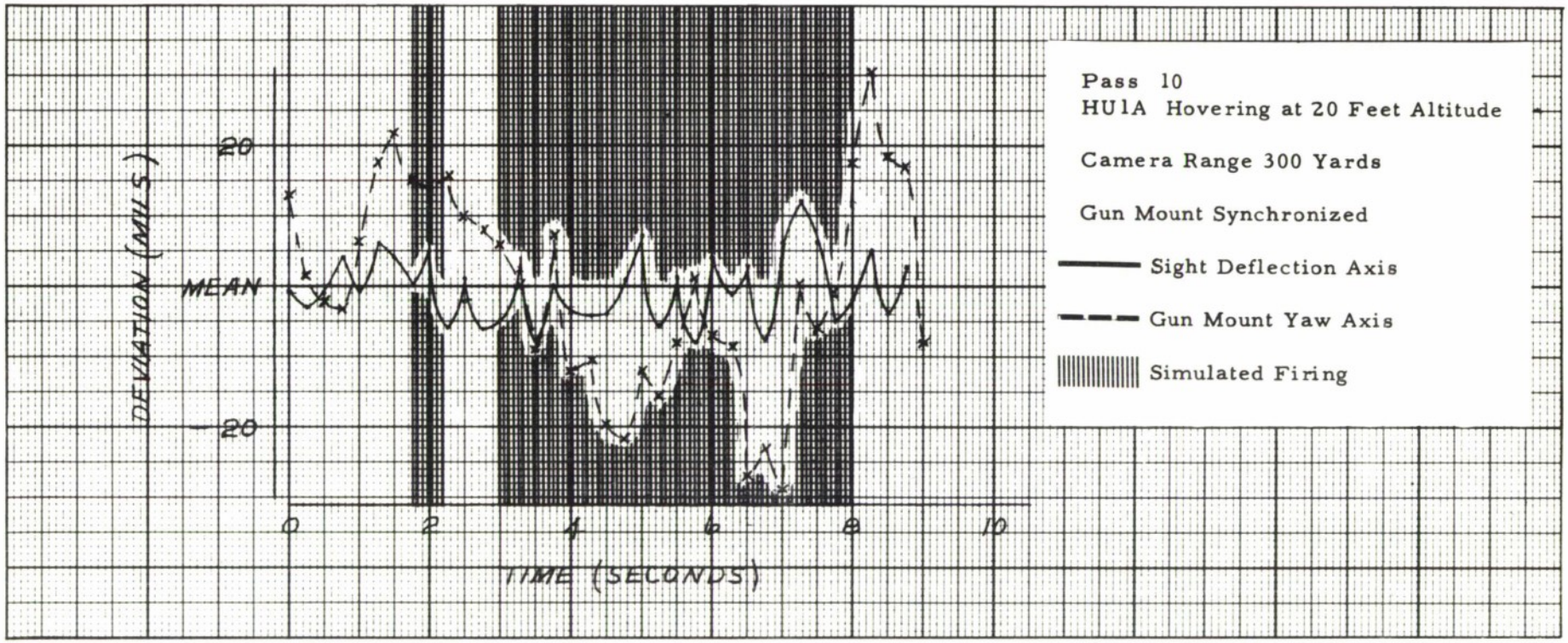
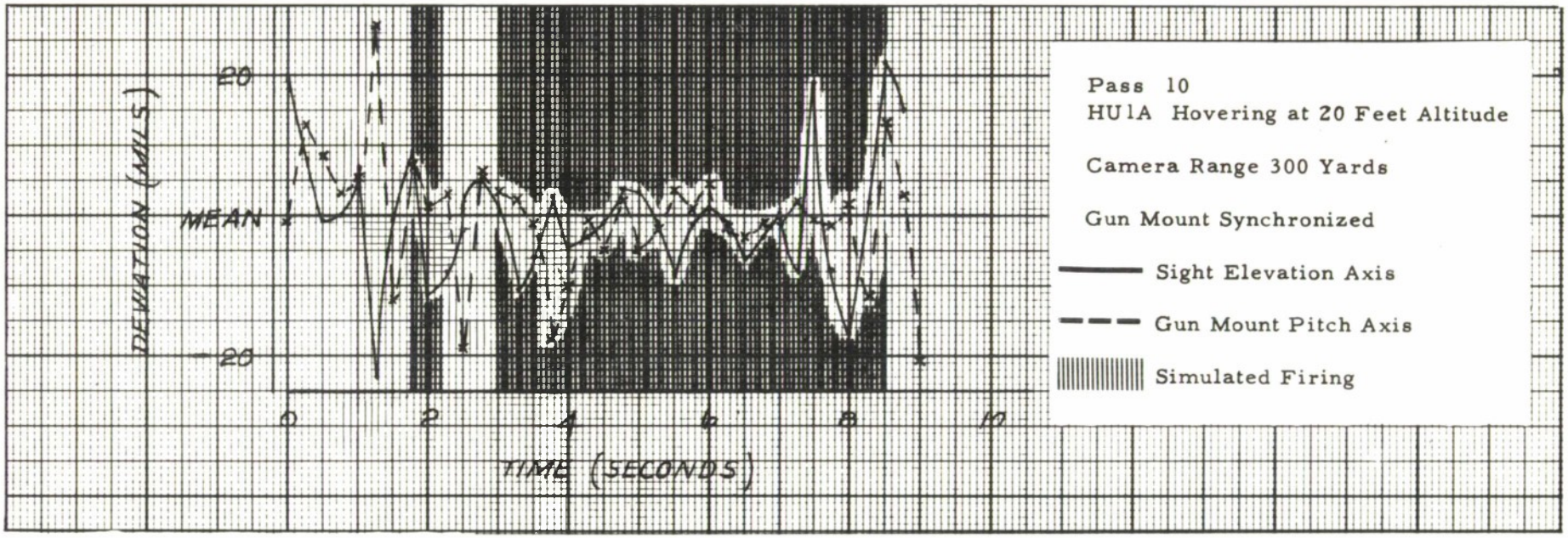
DEVIATION (MILS)
0
2
4
6
8
10
TIME (SECONDS)
Pass 6
HU1A at 60 Knots, 225 Feet Altitude
Camera Start Range 600 Yards
Gun Mount not Synchronized
Sight Deflection Axis
Aircraft Yaw Axis
Simulated Firing

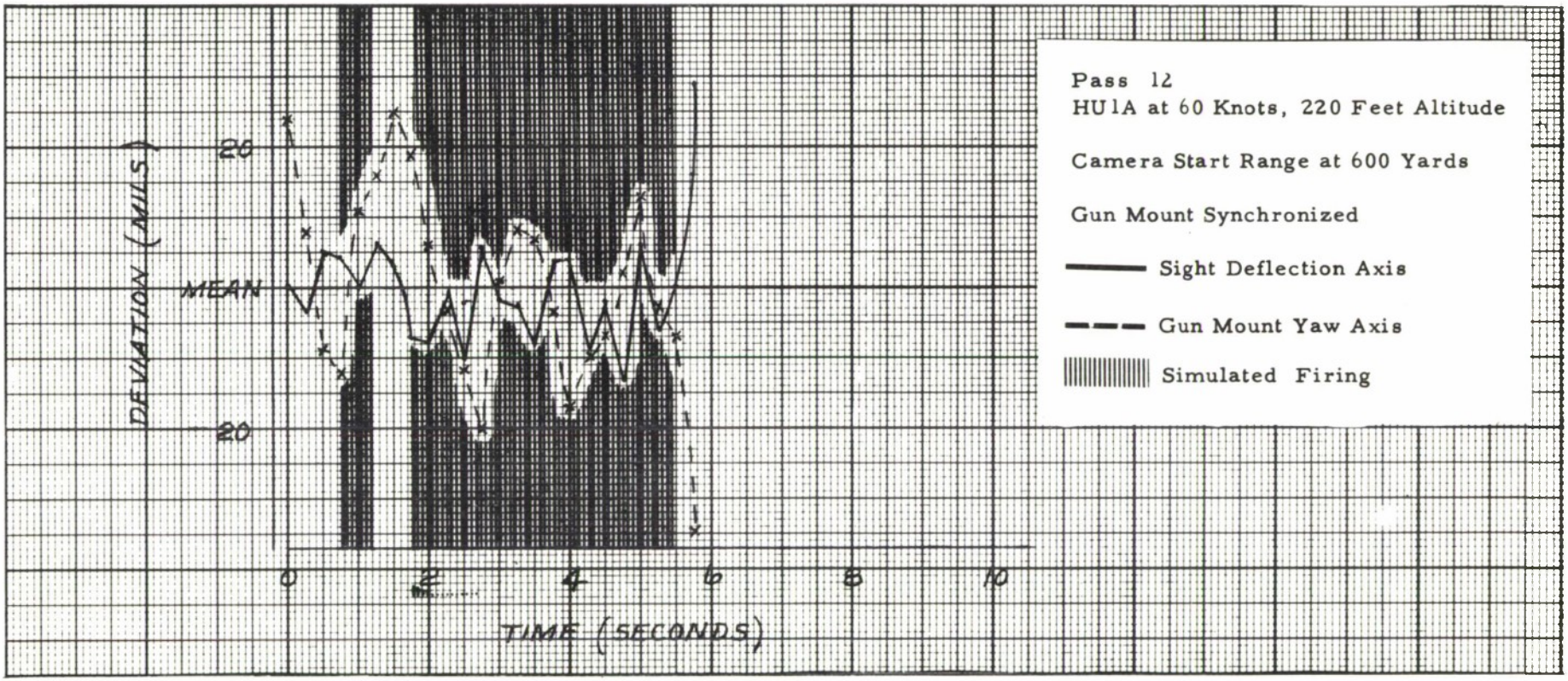

No Readings
Pass 6
HU1A at 60 Knots, 225 Feet Altitude
Camera Start Range 600 Yards
Gun Mount not Synchronized
Sight Elevation Axis
Aircraft Pitch Axis
Simulated Firing
DEVIATION (MILS)
MEAN
60
40
20
20
40
60
0
2
4
6
8
10
TIME (SECONDS)

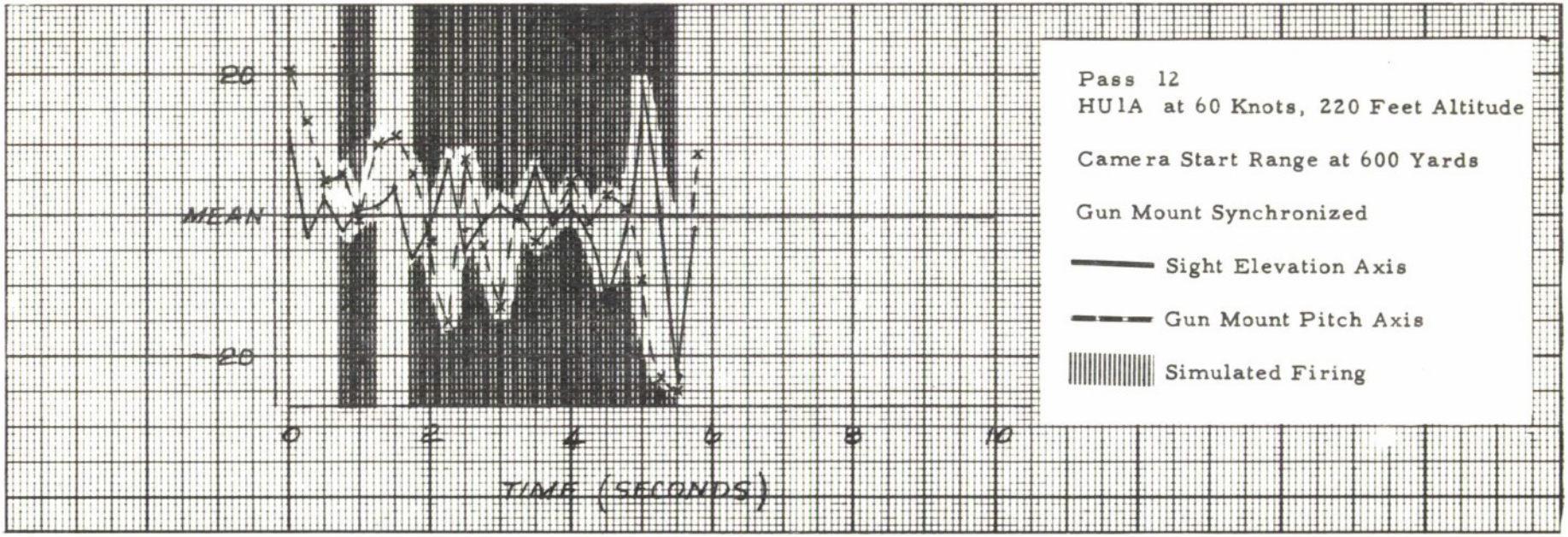

Pass 8
HU1A Hovering at 175 Feet Altitude
Camera Range 600 Yards
Gun Mount Synchronized
Sight Elevation Axis
Gun Mount Pitch Axis
Simulated Firing
DEVIATION (MILS)
20
MEAN
20
0
2
4
6
8
10
TIME (SECONDS)


Pass 8
HU1A Hovering at 175 Feet Altitude
Camera Range 600 Yards
Gun Mount Synchronized
Sight Deflection Axis
Gun Mount Yaw Axis
Simulated Firing
DEVIATION (MILS)
20
MEAN
20
0
2
4
6
8
10
TIME (SECONDS)


Pass 10
HU1A Hovering at 20 Feet Altitude
Camera Range 300 Yards
Gun Mount Synchronized
Sight Deflection Axis
Gun Mount Yaw Axis
Simulated Firing
20
MEAN
20
DEVIATION (MILS)
0
2
4
6
8
10
TIME (SECONDS)


20
MEAN
-20
DEFLECTION (MILS)
0
2
4
6
8
10
TIME (SECONDS)
Pass 10
HU1A Hovering at 20 Feet Altitude
Camera Range 300 Yards
Gun Mount Synchronized
Sight Elevation Axis
Gun Mount Pitch Axis
Simulated Firing


Pass 12
HU1A at 60 Knots, 220 Feet Altitude
Camera Start Range at 600 Yards
Gun Mount Synchronized
Sight Deflection Axis
Gun Mount Yaw Axis
Simulated Firing
DEVIATION (MILS)
20
MEAN
20
0
2
4
6
8
10
TIME (SECONDS)


2Θ
MEAN
-2Θ
0
2
4
6
8
10
TIME (SECONDS)
Pass 12
HU1A at 60 Knots, 220 Feet Altitude
Camera Start Range at 600 Yards
Gun Mount Synchronized
Sight Elevation Axis
Gun Mount Pitch Axis
Simulated Firing

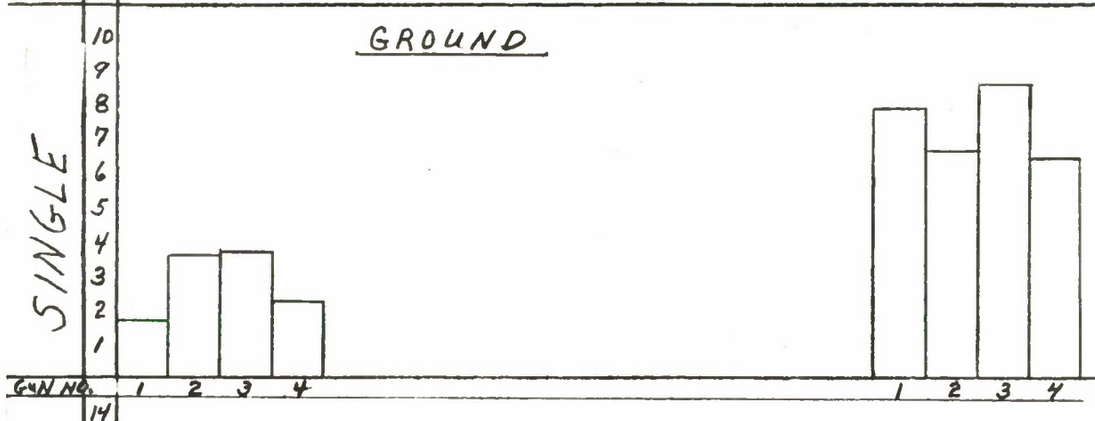
M73 QUAD SUBSYSTEM
HU-1A HELICOPTER

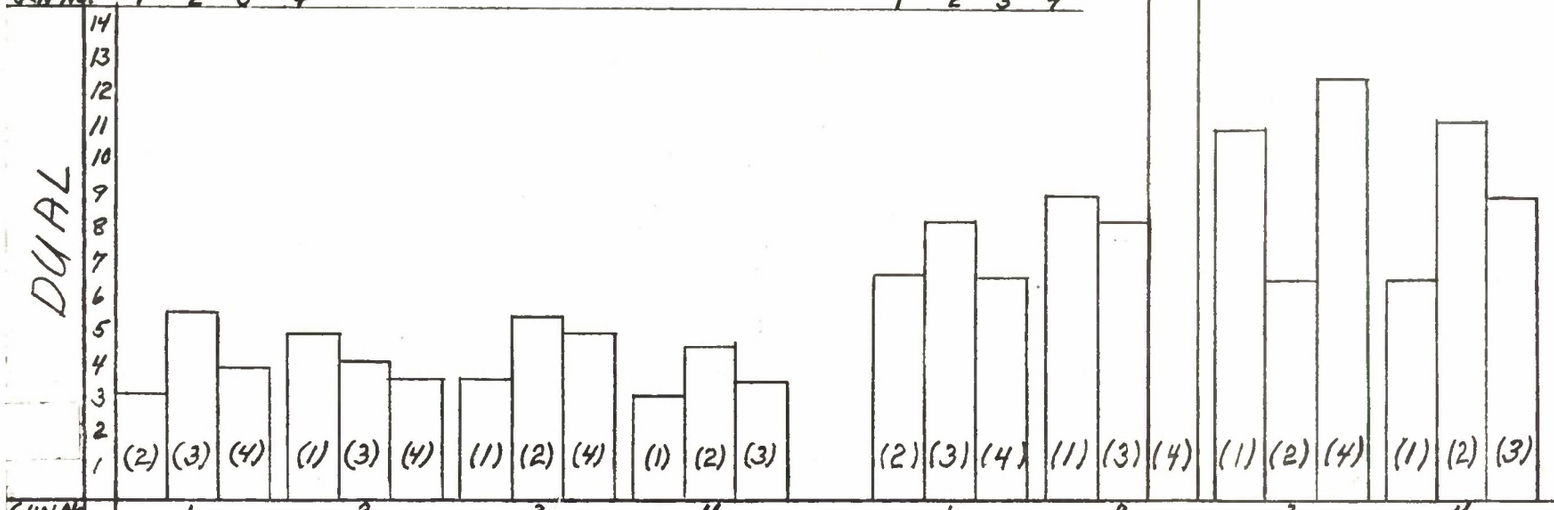
OY's

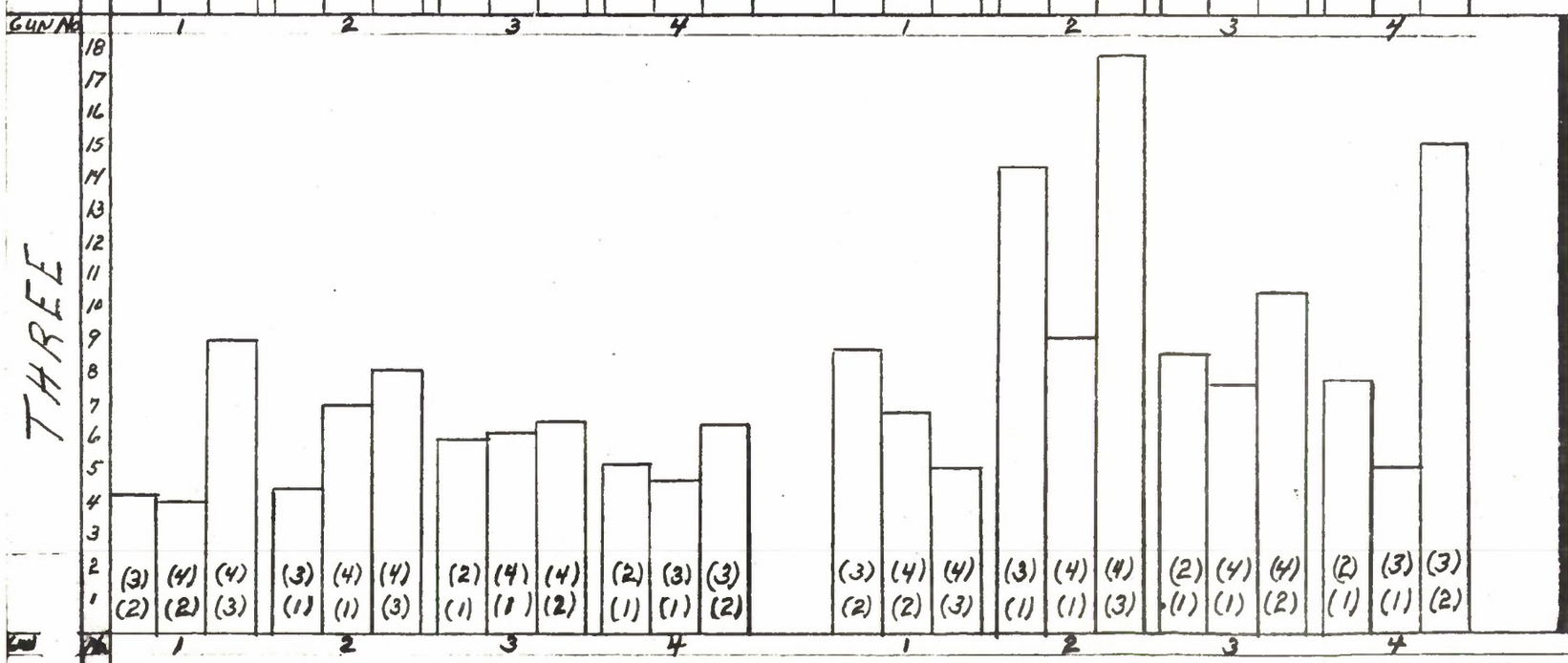
No. of Guns Firing

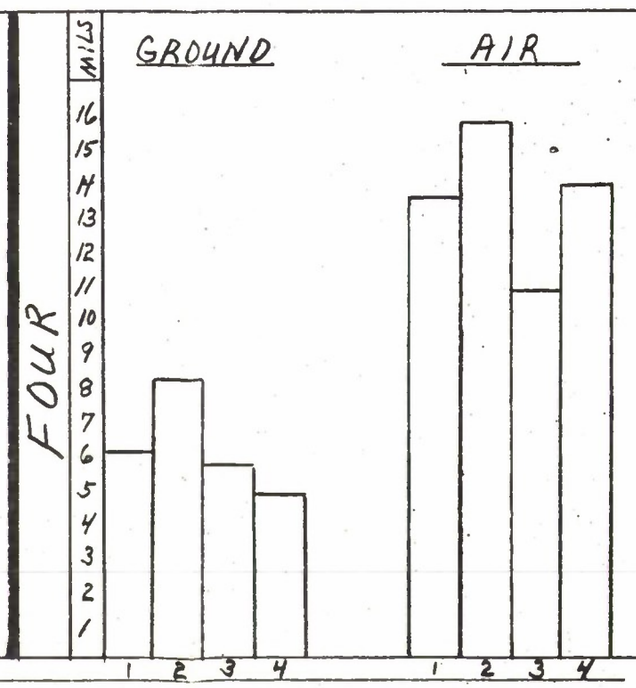
MILS

GUNS
1 - TOP RIGHT
2 - TOP LEFT
3 - BOTTOM RIGHT
4 - BOTTOM LEFT
( ) - FIRED AT SAME TIME AS SPECIFIED GUN.









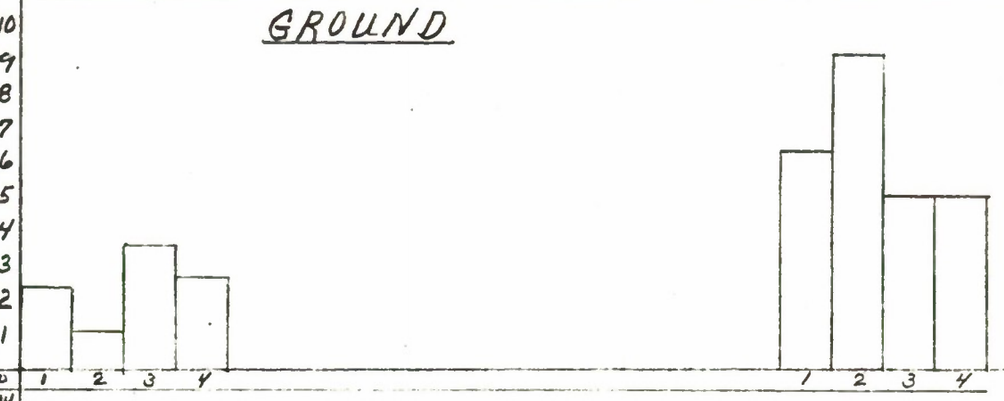
M23 QUAD SUBSYSTEM
HU-1A HELICOPTER

$\sigma_{x's}$

No. OF GUNS FIRING / MILS

SINGLE

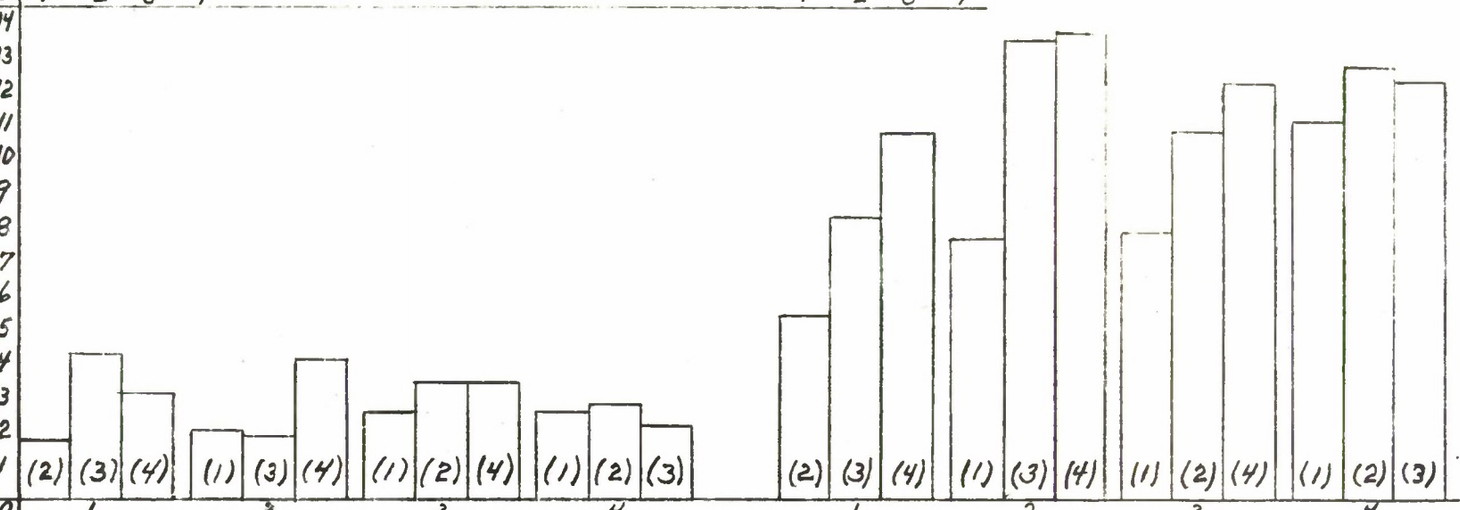
GROUND



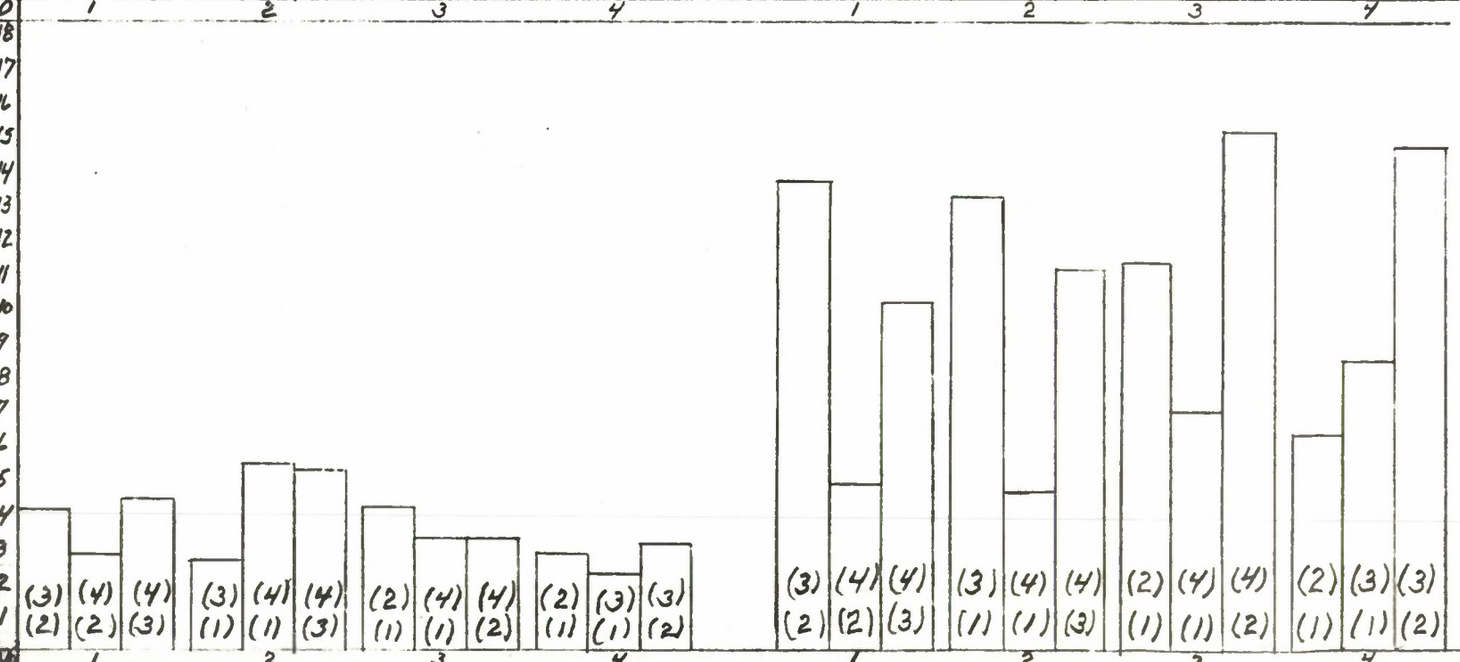
AIR

GUNS
1 - TOP RIGHT
2 - TOP LEFT
3 - BOTTOM RIGHT
4 - BOTTOM LEFT
( ) - FIRED AT SAME TIME AS SPECIFIED GUN

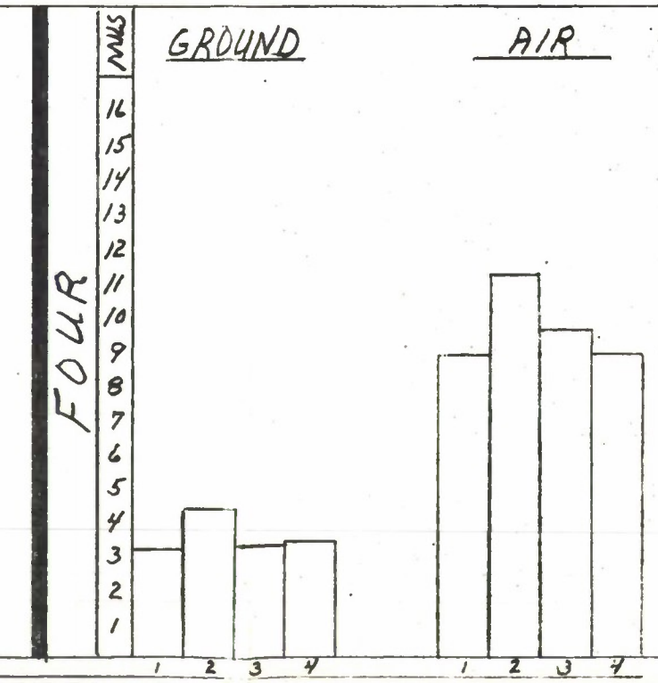
DUAL



THREE



FOUR



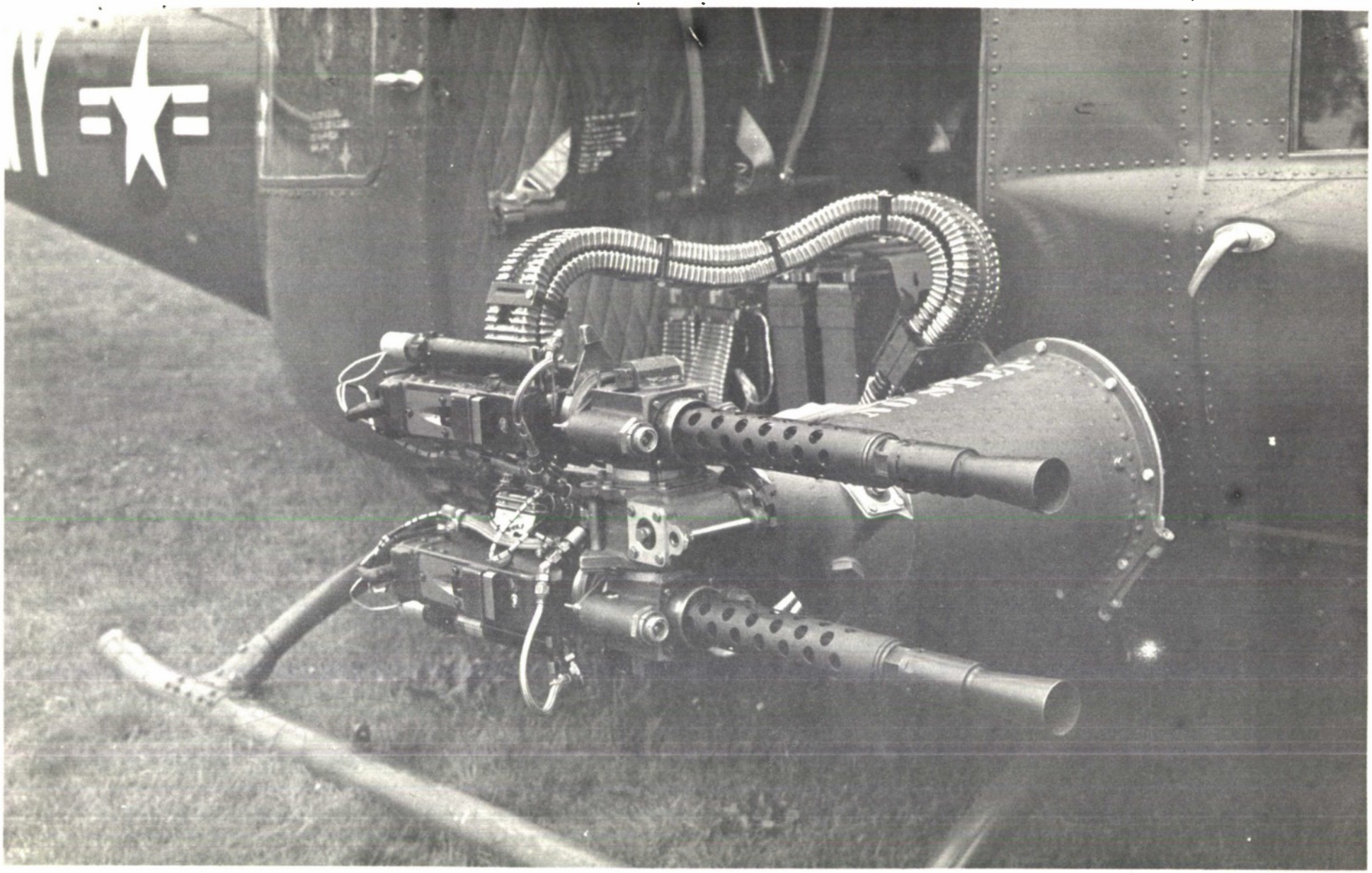
PHOTOGRAPHS (4)

1. HU-1A Helicopter with XM153 Armament Subsystem
2. Close-up of XM153 Armament Subsystem
3. H-13H Helicopter with XM1 Armament Subsystem
4. Close-up of XM1 Armament Subsystem

SPRINGFIELD ARMORY - ORDNANCE CORPS

Neg: 19-058-764/ORD-61 Date: 22 June 1961 Proj:

HU1A HELICOPTER
XM153C Armament Kit
XM156 Modified Kit
Four M73, Machine Guns



SPRINGFIELD ARMORY - ORDNANCE CORPS

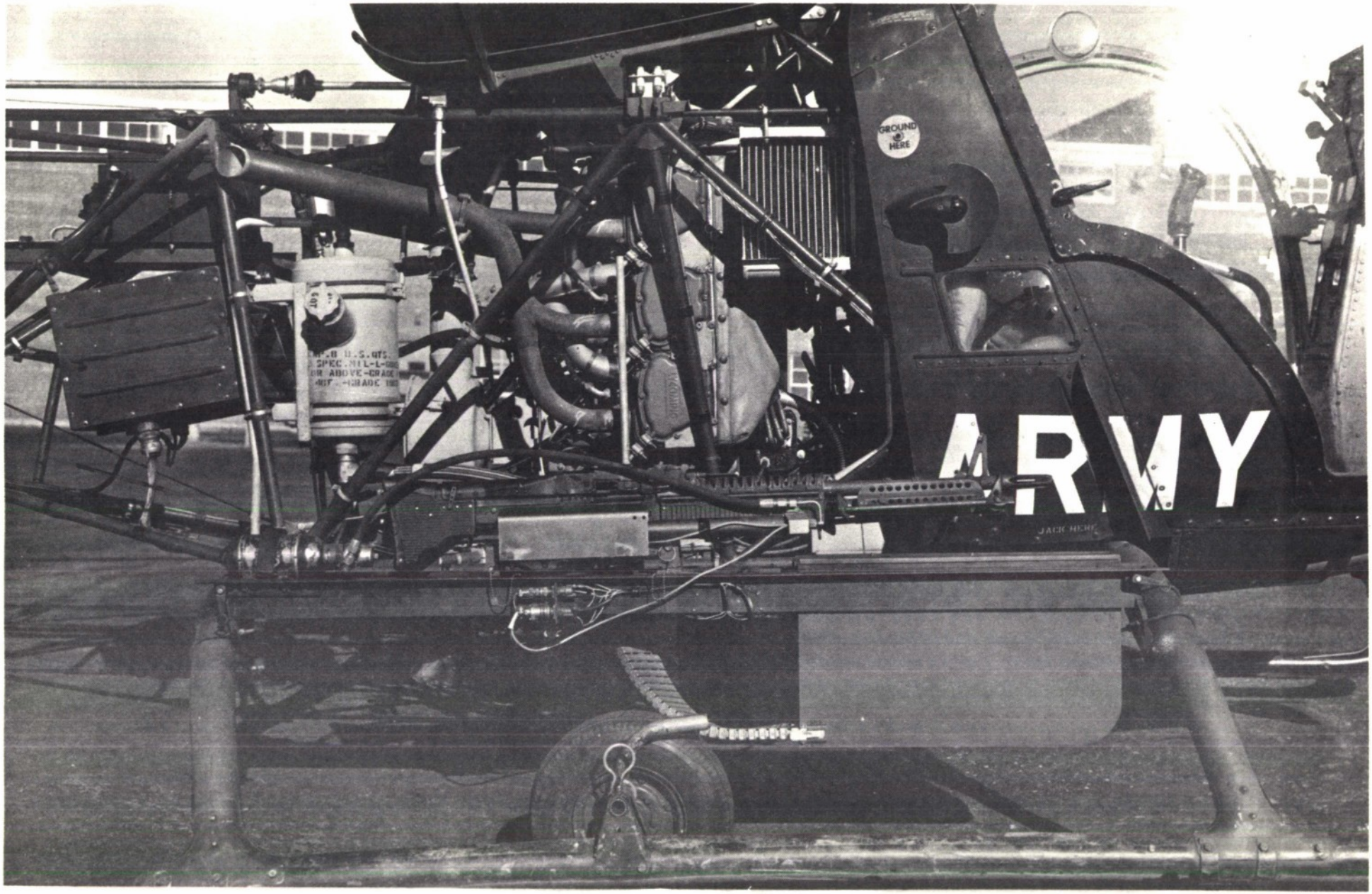
Neg: 19-058-765/ORD-61 Date: 22 June 1961 Proj:

HU1A HELICOPTER

Details XM153C Armament Kit

Neg: 19-058-1498/ORD-61 SPRINGFIELD ARMORY - ORDNANCE CORPS 26 Dec 1961

H-13H HELICOPTER ARMED WITH XM-1 ARMAMENT KIT, 7.62mm, M60 (EXP)
Right Side



Neg: 19-058-1494/ORD-61 SPRINGFIELD ARMORY - ORDNANCE CORPS 26 Dec 1961

H-13H HELICOPTER ARMED WITH XM-1 ARMAMENT KIT, 7.62mm, M60 (EXP)

Right Side

APPENDIX D

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